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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
09/055,201	04/03/98	BROWN W	[illegible]

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EXAMINER	
ZERVIGON,R	

ART UNIT	PAPER NUMBER
1763	5

DATE MAILED: 11/25/98

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

FILE COPY

Office Action Summary	Application No. 09/055,201	Applicant(s) Brown, W., Herchen, H., Welch, M.D.
	Examiner Rudy Zervigon	Group Art Unit 1763

☐ Responsive to communication(s) filed on ______.

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

A shortened statutory period for response to this action is set to expire *3* month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

Disposition of Claims

☒ Claim(s) *1-30* is/are pending in the application.

Of the above, claim(s) *17-23* is/are withdrawn from consideration.

☐ Claim(s) ______ is/are allowed.

☒ Claim(s) *1-16 and 24-30* is/are rejected.

☐ Claim(s) ______ is/are objected to.

☒ Claims *17-23* are subject to restriction or election requirement.

Application Papers

☒ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☒ The drawing(s) filed on *Apr 3, 1998* is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ______ is ☐approved ☐disapproved.

☒ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☐ received.

☐ received in Application No. (Series Code/Serial Number) ______.

☐ received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

*Certified copies not received: ______.

☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

☒ Notice of References Cited, PTO-892

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). *4*

☐ Interview Summary, PTO-413

☒ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Notice of Informal Patent Application, PTO-152

--- SEE OFFICE ACTION ON THE FOLLOWING PAGES ---

DETAILED ACTION

Drawings

1. The drawings are objected to under 37 CFR 1.83(a) because they fail to show item 75 as described in the specification. Any structural detail that is essential for a proper understanding of the disclosed invention should be shown in the drawing. MPEP § 608.02(d). Correction is required.

Specification

The disclosure is objected to because of the following informalities: Line 20 page 8. Miss spelling of vise.

Appropriate correction is required.

Election/Restriction

2. Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-10, 11-16, 24-30 drawn to a gas treatment apparatus, process chamber, and computer program product, classified in class 156, subclass 345

II. Claim 17-23, drawn to a method of reducing the hazardous gas content, classified in class 34, subclass 467.

3. The inventions are distinct, each from the other because of the following reasons: Inventions I, and II are distinct from one another by contrasting the class and subclass definitions under which they fall:

CLASS 156 Subclass Definition 345 :

Apparatus under the class definition for treating a base with an etchant fluid the device having means causing the etchant fluid to contact the base in discontinuous or nonuniform manner.

CLASS 34 Subclass Definition 467 :

Treatment of gas or vapor:

Process under subclass 443 involving any one or a combination of: (a) the use of gases having different degrees of vapor concentration regardless of how obtained; (b) changing or maintaining constant the vapor concentration by adding or removing gas or vapors; (c) adding any characteristic of material to or removing any characteristic of material from the treating gas or vapor.

The inventions are distinct if it can be shown that either: (1) the process as claimed can be practiced by another materially different apparatus, or (2) the apparatus as claimed can be used to practice another and materially different process. (MPEP § 806.05(e)). In this case the apparatus as claimed in invention I can be used to treat a host of process effluents with varying characteristics do to the physical (nonspecific) nature of treatment. The process claimed in invention II can be practiced by another materially different apparatus such a kiln incinerator.

4. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

5. During a telephone conversation with patent counsel Ashok K. Janah on October 23, 1998 a provisional election was made with traverse to prosecute the invention of a process chamber, claimed accordingly in claims 11-16, 24,25,26, and 27. Upon further review of the application, after the initial telephone conversation, it was concluded that the following claims did not pose a serious burden on the examiner as detailed in MPEP § 803.02 § 806.04(a) - (j), § 808.01(a) and § 808.02. As a result the following claims were examined on the merits:

I. Gas treatment apparatus detailed in claims 1-10.

II. Process chamber detailed in claims 24-27.

III. Computer program product detailed in claims 28-30.

Claims 17-23 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

6. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a petition under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(I).

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claims 1,2,3,4,5,8 are rejected under 35 U.S.C. 102(b) as being anticipated by Chiu. Chiu discloses an exhaust system apparatus, plasma extraction reactor (lines 66-68, column 2), for treating effluent gas streams from plasma processes (Figures 1-6). Chiu specifically applies the plasma extraction reactor to utility in the removal of vapor phase environmental contaminants from effluent gas streams generated by semiconductor processing equipment generating plasma states (line 61-68, column 2). Chiu also discloses the location of his plasma extraction reactor relative to a CVD process (lines 1-18, column 6) and more specifically to a GENUS Model 8402 LPCVD reactor (lines 53-58, column 8). Chiu discloses an embodiment where radio frequency driven parallel electrode plates, as part of the plasma extraction reactor, are positioned to intercept effluent gas from the upstream production site and subsequently deposit the gas on the electrode surfaces by nucleation (line 61-68, column 2 through, lines 1-7, column 3, lines 18-23, column 5). Variations on contact area of the reacting effluent are considered and integrated into the design by altering the geometry of the flow path (lines 24-45, column 3). Among the geometric design considerations of the internal flow chamber put forth by Chiu include a flow path length to ensure sufficient removal of the effluent gas (lines 24-30, column 3), a high ratio of electrode area to reactor volume (lines 11-23, column 3),

electrode surface area to flow rate of gas to be optimally set for vapor removal capacity (lines 30-37, column 3). According to the following demonstration, the requirement that the flow path be of sufficient length to provide an effluent gas residence time of at least 0.01s in the exhaust plasma extraction reactor stipulated in claim 3 is implicitly satisfied under the teachings of Chiu[1]. Chiu does not explicitly make reference to the flow regime, either turbulent or laminar, when passing the effluent gas through the plasma extraction reactor. Chiu also does not explicitly make reference to the surface characteristics of the flow path. However, because Chiu discusses variations of the internal flow chamber geometry as well as flow characteristics of the effluent gas in the range of values outlined in lines 8-45 column 3 Chiu is implicitly favoring laminar, unhindered, flow of the effluent gas through his plasma extraction reactor. Any author describing internal fluid flow, such as Chiu, would consider that the direction of fluid flow (velocity vector), substantially distant from the boundary layer, and the tangent to the surface of the encasement are an implicitly parallel. Chiu does point out that in order to reduce the size of his plasma extraction reactor, the processing pipe can be convoluted (lines 57-62, column 4) as apposed to the larger processing space required for a linear plasma processing apparatus. Projections or recesses, beyond boundary layer variability, are also implicitly taught by Chiu under the observation that the geometric design considerations of the internal flow chamber and flow rates for sufficient removal put forth by Chiu (lines 11-37, column 3) would have to be reinvestigated/recalculated if projections or recesses were present in Chiu's plasma extraction reactor. Figures 1-6 also support flow surfaces absent of projections and or recesses.

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[1]Refer to calculation sheet.

9. Claim 6 is rejected under 35 U.S.C. 102(b) as being clearly anticipated by Fujitsu, Ltd..

Claim Rejections - 35 USC § 103

10. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

11. Claim 7 is rejected under 35 U.S.C. 103(a) as being unpatentable over Arai. Arai discloses a microwave induced plasma gas generator. A microwave power generator (item 1, Figure 1) utilizing a microwave tube in conjunction with a magnetron is applied to a waveguide (item 2, Figure 1). Microwave irradiation is subsequently conveyed through an isolator (item 3, Figure 1), power monitor (item 4 Figure 1), and a tuner (item 5 Figure 1) and concludes in an irradiation furnace (item 6, Figure 1). A metal tube (item 8, Figure 1) protruding from the irradiation furnace maintains a magnetic flux while gas pipe (item 9, Figure 1) carrying raw, unionized gas, penetrates metal tube(8) and irradiation furnace (6). The gas pipe(9) originates from a valve and tank assembly (items 11 and 12 respectfully, Figure 1) upstream of the gas flow direction and terminates at a vacuum pump (item 14, Figure 1). The unionized gas carried by the gas pipe penetrating the ionization chamber is energized in the irradiation furnace by allowing microwave energy to penetrate through its dielectric length (item 10, Figure 1). The dielectric material disclosed is allowed to be made of a plasma environment resistant material such as quartz (line 32-34, column 30). The gas outlet extension (item 9c, Figure 2, Figure 7) is also allowed to be constructed of a dielectric material (line 66-68, column

5). Energized gas originating from the irradiation furnace is then convey across a pressure drop through the reaction chamber (item 13, Figure 1) and into the vacuum pump. Under the first embodiment shown in Figure 2 Arai adds a perforated support board (item 27, Figure 2) stabilizing a substrate object (item 28, Figure 2). And, as in the disclosure describing Figure 1, maintains all components that distribute and activate the raw unionized gas from the process gas supply. Arai additionally enhances the disclosure described in Figure 1 by thermally isolating and irradiation encasing the ionization chamber zone with upper and lower coolant surfaces (items 20 and 21 respectfully, Figure 2) conveying microwave absorbing water. Arai, however, lacks a specific treatment apparatus for reducing the hazardous gas content of the effluent gas. Arai also lacks the specific selection of a ceramic such as a monocrystalline sapphire as the material of choice making up the exhaust tube. Considering the art disclosed by Arai, one of ordinary skill in the production of a plasma gas by the method disclosed by Arai's activated gas generator would consider one of two options for off-gas abatement. One method a person of ordinary skill would implement to limit the production of the regulated off-gasses would be to construct an off-gas recycle system. The system would collect the process gas from the reaction chamber (13, Figure 2) via the exhaust tube (30, figure 2) once the containment of such a gas reached a capacity limit. Through a series of added isolation vales, the effluent collected could then be refluxed into the activated gas generator now implemented as an exhaust gas treatment unit containing all the attributes discussed in this claim and its dependent claim. An alternative method for treating the off-gas generated from Arai's activated gas generator is to replicate Arai's generator then connect, in series, the effluent gas produced from

the generator at exit pipe (30, figure 2) with the entrance pipe (9b, Figure 2) of the second activated gas generator now implemented as an exhaust gas treatment unit, the two units in series, contain all the attributes discussed in this claim and its dependent claim. The motivation for off-gas abatement would derive from provisions of 40CFR Part 82. 40CFR Part 82 is the Clean Air Act final rule on the protection of stratospheric ozone from the halocarbon contaminants listed under class I and class II in sections 604 and 606 of the Clean Air Act. The person of ordinary skill in the art at the time the invention was made would be motivated to select a material, such as a ceramic represented as a monocrystalline sapphire, for the exhaust tube that would optimally service its function, namely as a conduit for the effluent heated gas existing in a corrosive plasma environment in addition to transmission of microwave energy.

12. Claims 10,27,28,29,30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chiu in view of Otsubo et.al., Fujitsu Ltd.. Chiu discloses an exhaust system apparatus, plasma extraction reactor (lines 66-68, column 2), for treating effluent gas streams from plasma processes (Figures 1-6). Chiu specifically applies the plasma extraction reactor to utility in the removal of vapor phase environmental contaminants from effluent gas streams generated by semiconductor processing equipment generating plasma states (line 61-68, column 2). Chiu also discloses the location of his plasma extraction reactor relative to a CVD process (lines 1-18, column 6) and more specifically to a GENUS Model 8402 LPCVD reactor (lines 53-58, column 8). Chiu discloses a monitoring system taught in the experimental section of his patent. Under Chiu's teachings, the plasma extraction reactor is located downstream of a plasma generation unit (GENUS Model 8402 LPCVD) and a residual gas

analyzer is connected to the effluent line of the plasma generation unit. The residual gas analyzer provides an output signal in direct relation to the hazardous gas content of the effluent as is demonstrated in Figures 7 through 10. Chiu discloses an embodiment where radio frequency driven parallel electrode plates, as part of the plasma extraction reactor, are positioned to intercept effluent gas from the upstream production site and subsequently deposit the gas on the electrode surfaces by nucleation (line 61-68, column 2 through, lines 1-7, column 3, lines 18-23, column 5). Variations on contact area of the reacting effluent are considered and integrated into the design by altering the geometry of the flow path (lines 24-45, column 3). Among the geometric design considerations of the internal flow chamber put forth by Chiu include a flow path length to ensure sufficient removal of the effluent gas (lines 24-30, column 3), a high ratio of electrode area to reactor volume (lines 11-23, column 3), electrode surface area to flow rate of gas to be optimally set for vapor removal capacity (lines 30-37, column 3). Chiu, however, does not specifically disclose a computer controller system comprising a computer readable medium that independently provides actions according to the conditions set form in the computer readable algorithms. Otsubo et.al. teaches a control and etching apparatus for monitoring, controlling, and manufacturing a plasma and the products originating from such processes. Monitoring the plasma etching conditions is accomplished through optical signal processing utilizing a TV camera (item 19, Figure 6), a band-pass filter (item 33, figure 6), and other associated circuitry (lines 8-22, column 5). Figure 6 details a specific component termed an end point decision device (item 20, Figure 6, lines 23-32, column 5). The end point decision device consists of a threshold value signal generator circuit (35b) that receives the output signal Va of the average value

extraction circuit (35a) that is connected to the comparitor circuit (34) (lines 50-65, column 5). Otsubo et.al. further discloses that the disclosed circuitry can be altered to any desired triggering error signal. Based on the relative position of the input signal to the error signal, a desired action can be taken to control the process (lines 59-65, column 5), namely stopping the etching process. Control of Otsubo et.al.'s processing conditions is mediated through decision making of the end point decision device which provides power to the radio frequency power source (16) that directly influences the plasma and hence the processing conditions. In another embodiment shown in Figure 8, Otsubo et.al. end point decision and control device (20) consists of a computer readable sampling circuit (item 41, figure 8, lines 4-13, column 7). The process control algorithm set forth by Otsubo et.al. represent a template of knowledge from which Chiu's effluent residual gas analyzer can be obviously modified by, for example, coupling the signal from Chiu's RGA to the control and decision circuitry taught by Otsubo et.al.. Instead of a optical decision based algorithm, a setpoint for concentration can be used from the RGA. The operating power level, and hence the processing conditions, of the gas energizer is the same for Otsubo et al.'s terminal control point (item 16, all Figures). Implementations of alarming conditions would be obvious to one of ordinary skill in the art in view of the teachings of Otsubo et.al. with the same additions to Arai and modifications of Otsubo et.al.. More related prior art by Fujitsu Ltd. (sited by Chiu) disclose gas effluent treatment methods from plasma processing operations. Fujitsu Ltd. are all foreign references with only translated titles and abstracts available under the WPAT/JAPIO databases. As of the date of this document the U.S. Patent Translations Department is working on translating each patent or finding an English equivalent document.

Translations of the sited documents will be provided to the applicant in the near future. Under the titles and abstracts of this document Fujitsu Ltd. (JP51129868A), discloses an apparatus for the treatment of waste gas generated from a semiconductor production process. The gas processing of the plasma effluent is accomplished by oxidation with oxygen or hydrogen peroxide in a plasma generated environment. Reagent gas addition to the processing environment to reduce the environmental impact to the environment is disclosed by Fujitsu Ltd.. Process termination based on the decision circuitry is disclosed by Otsubo et.al.. The person of ordinary skill in the art of designing and controlling the amount of plasma gas that is processed, at the time the invention was made, would find it obvious to implement slight modifications such as coupling the signal produced from Chiu's residual gas analyzer to the control algorithm set forth by Otsubo et.al. Motivation for this action has already been presented, namely source emission restrictions.

13. Claims 11,12,13,14,25 are rejected under 35 U.S.C. 103(a) as being unpatentable over Arai in view of Chiu, Ransch, Fujitsu Ltd., Itoga et.al., Nevers. Arai discloses a microwave induced plasma gas generator. A microwave power generator (item 1, Figure 1) utilizing a microwave tube in conjunction with a magnetron is applied to a waveguide (item 2, Figure 1). Microwave irradiation is subsequently conveyed through an isolator (item 3, Figure 1), power monitor (item 4 Figure 1), and a tuner (item 5 Figure 1) and concludes in an irradiation furnace (item 6, Figure 1). A metal tube (item 8, Figure 1) protruding from the irradiation furnace maintains a magnetic flux while gas pipe (item 9, Figure 1) carrying raw, unionized gas, penetrates metal tube(8) and irradiation furnace (6). The gas pipe(9) originates from a valve and tank assembly (items 11 and 12 respectfully, Figure 1)

upstream of the gas flow direction and terminates at a vacuum pump (item 14, Figure 1). The unionized gas carried by the gas pipe penetrating the ionization chamber is energized in the irradiation furnace by allowing microwave energy to penetrate through its dielectric length (item 10, Figure 1). The dielectric material disclosed is allowed to be made of a plasma environment resistant material such as quartz (line 32-34, column 30). The gas outlet extension (item 9c, Figure 2, Figure 7) is also allowed to be constructed of a dielectric material (line 66-68, column 5). Energized gas originating from the irradiation furnace is then convey across a pressure drop through the reaction chamber (item 13, Figure 1) and into the vacuum pump. Under the first embodiment shown in Figure 2 Arai adds a perforated support board (item 27, Figure 2) stabilizing a substrate object (item 28, Figure 2). And, as in the disclosure describing Figure 1, maintains all components that distribute and activate the raw unionized gas from the process gas supply. Arai additionally enhances the disclosure described in Figure 1 by thermally isolating and irradiation encasing the ionization chamber zone with upper and lower coolant surfaces (items 20 and 21 respectfully, Figure 2) conveying microwave absorbing water. Arai, however, lacks the application of his disclosed activated gas generator as a plasma effluent gas processing unit such as Chiu's plasma extraction reactor's. Arai also lacks a gas analyzer for monitoring the hazardous gas content of the effluent exhaust gas and providing an output signal in relation to the hazardous gas content of the effluent. Chiu discloses an exhaust system apparatus, plasma extraction reactor (lines 66-68, column 2), for treating effluent gas streams from plasma (Figures 1-6). Chiu specifically applies the plasma extraction reactor to utility in the removal of vapor phase environmental contaminants from effluent gas streams generated by semiconductor processing

equipment generating plasma states (line 61-68, column 2). Chiu also discloses the location of his plasma extraction reactor relative to a CVD process (lines 1-18, column 6) and more specifically to a GENUS Model 8402 LPCVD reactor (lines 53-58, column 8). Chiu discloses an embodiment where radio frequency driven parallel electrode plates, as part of the plasma extraction reactor, are positioned to intercept effluent gas from the upstream production site and subsequently deposit the gas on the electrode surfaces by nucleation (line 61-68, column 2 through, lines 1-7, column 3, lines 18-23, column 5). Variations on contact area of the reacting effluent are considered and integrated into the design by altering the geometry of the flow path (lines 24-45, column 3). Among the geometric design considerations of the internal flow chamber put forth by Chiu include a flow path length to ensure sufficient removal of the effluent gas (lines 24-30, column 3), a high ratio of electrode area to reactor volume (lines 11-23, column 3), electrode surface area to flow rate of gas to be optimally set for vapor removal capacity (lines 30-37, column 3). According to the following demonstration, the requirement that the flow path be of sufficient length to provide an effluent gas residence time of at least 0.01s in the exhaust plasma extraction reactor stipulated in claim 12.2 is implicitly satisfied under the teachings of Chiu[2]. Chiu does not explicitly make reference to the flow regime, either turbulent or laminar, when passing the effluent gas through the plasma extraction reactor. Chiu also does not make reference to the surface characteristics of the flow path. More related prior art by Ransch, Fujitsu Ltd., and Itoga et.al. (all sited by Chiu) disclose gas effluent treatment methods from plasma processing operations. Ransch, Fujitsu Ltd., and Itoga et.al. are all

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[2]Refer to calculation sheet.

foreign references with only translated titles and abstracts available under the WPAT/JAPIO databases. As of the date of this document the U.S. Patent Translations Department is working on translating each patent or finding an English equivalent document. Translations of the sited documents will be provided to the applicant in the near future. Under the titles and abstracts of these documents Ransch (DD-215706) discloses an invention entitled "Plasma waste gasses cleaning - by passing plasma between reactant plate and vacuum container walls". The waste gases from plasma-etching operations are "cleaned" by passing the gasses in an evacuated chamber over a reactant material in the presence of an inert gas. The assignee, Fujitsu Ltd. (JP51129868A), discloses an apparatus for the treatment of waste gas generated from a semiconductor production process. The gas processing of the plasma effluent is accomplished by oxidation with oxygen or hydrogen peroxide in a plasma generated environment. Itoga et.al. (JP51-129868) disclose "A process for treatment of waste gas". A waste gas treatment process used in the semi-conductor industry is detailed by Itoga et.al.. Arai is recognized as lacking a waste gas processing appendage that would receive the effluent from the plasma generating operations upstream. Noel De Nevers is the author of <u>Fluid Mechanics</u>[3]. Chiu is recognized as lacking a detailed disclosure of a specific plasma generating instrument that first generates a plasma gas, processes a substrate in a reaction chamber, and subsequently discharges the effluent gas from the processing step. Chiu's plasma extraction reactor is disclosed as an instrument that will treat production effluents from semiconductor processing equipment. The deficiencies of the

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[3]Nevers, Noel de, <u>Fluid Mechanics</u>, Addison-Wesley Publishing Company, June 1977, Chapter 6, pp161 sixth paragraph.

remaining inventors Ransch, Fujitsu Ltd., Itoga et.al. relative to the contents of this application for a letters patent can not be fully ascertained until the complete translations of the documents are processed. However, under the disclosures of Arai in view of Chiu a person of ordinary skill in the plasma gas production and processing art at the time the invention was made would be motivated by the provisions of 40CFR Part 82. 40CFR Part 82 is the Clean Air Act final rule on the protection of stratospheric ozone from the halocarbon contaminants listed under class I and class II in sections 604 and 606 of the Clean Air Act. Coupling the technology of Arai in view of the Chiu to arrive at a semiconductor processing apparatus that will comply 40CFR Part 82 is an action that one of ordinary skill in the plasma gas manufacturing art, at the time the invention was made, would have to implement.

Nevers reproduces the definition of the Reynolds number in chapter 6 of Fluid Mechanics[4] with geometry for the internal flow condition of fluid in a pipe. However, one of ordinary skill in the design of a process chamber for processing a substrate and reducing the emissions of hazardous gas to the environment, at the time the invention was made, would consider the maximum flow velocity dictated by Chiu (10min/cm = 0.16mm/s = 0.16*10E-3 m/s, line 33, column 3) to be representative of laminar flow due to the dependence of the Reynolds number on fluid velocity, the diameter of the flow path, density and viscosity of the gas to be processed. The small magnitude fluid velocity with the considerably small flow diameter (proportional to sqrt((4*volume)/(pi))) and the low density of

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[4]Nevers, Noel de, Fluid Mechanics, Addison-Wesley Publishing Company, June 1977, Chapter 6, pp161 sixth paragraph.

plasma gasses would place the Reynolds number below the 4000 considered to represent the transition from laminar to turbulent flow in pipe flow geometries. Motivation for flow regime placement would be expected to come from considerations of mass transport to regions where the effluent gas is reacted such as near the RF powered plates.

14. Claims 9,15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chiu. Chiu discloses an exhaust system apparatus, plasma extraction reactor (lines 66-68, column 2), for treating effluent gas streams from plasma (Figures 1-6). Chiu specifically applies the plasma extraction reactor to utility in the removal of vapor phase environmental contaminants from effluent gas streams generated by semiconductor processing equipment generating plasma states (line 61-68, column 2). Chiu also discloses the location of his plasma extraction reactor relative to a CVD process (lines 1-18, column 6) and more specifically to a GENUS Model 8402 LPCVD reactor (lines 53-58, column 8). Chiu discloses an embodiment where radio frequency driven parallel electrode plates, as part of the plasma extraction reactor, are positioned to intercept effluent gas from the upstream production site and subsequently deposit the gas on the electrode surfaces by nucleation (line 61-68, column 2 through, lines 1-7, column 3, lines 18-23, column 5). Variations on contact area of the reacting effluent are considered and integrated into the design by altering the geometry of the flow path (lines 24-45, column 3). Among the geometric design considerations of the internal flow chamber put forth by Chiu include a flow path length to ensure sufficient removal of the effluent gas (lines 24-30, column 3), a high ratio of electrode area to reactor volume (lines 11-23, column 3), electrode surface area to flow rate of gas to be optimally set for vapor removal capacity (lines 30-37, column 3). Chiu,

however, does not specifically detail the existence of a distributer plate located at the inlet of the exhaust tube (Chiu's inlet tube, item 14 Figure 1). Considering the necessity for surface contact of the effluent molecules or ions to reduce or oxidize these species, one of ordinary skill in the art at the time the invention was made would consider the restriction of flow to the surface of the Chiu's electrodes an obvious enhancement to assist what would other wise be a diffusion rate limiting step.

15. Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Arai in view of Ransch, Fujitsu Ltd., Itoga et.al.. Arai discloses a microwave induced plasma gas generator. A microwave power generator (item 1, Figure 1) utilizing a microwave tube in conjunction with a magnetron is applied to a waveguide (item 2, Figure 1). Microwave irradiation is subsequently conveyed through an isolator (item 3, Figure 1), power monitor (item 4 Figure 1), and a tuner (item 5 Figure 1) and concludes in an irradiation furnace (item 6, Figure 1). A metal tube (item 8, Figure 1) protruding from the irradiation furnace maintains a magnetic flux while gas pipe (item 9, Figure 1) carrying raw, unionized gas, penetrates metal tube(8) and irradiation furnace (6). The gas pipe(9) originates from a valve and tank assembly (items 11 and 12 respectfully, Figure 1) upstream of the gas flow direction and terminates at a vacuum pump (item 14, Figure 1). The unionized gas carried by the gas pipe penetrating the ionization chamber is energized in the irradiation furnace by allowing microwave energy to penetrate through its dielectric length (item 10, Figure 1). The dielectric material disclosed is allowed to be made of a plasma environment resistant material such as quartz (line 32-34, column 30). The gas outlet extension (item 9c, Figure 2, Figure 7) is also allowed to be constructed of a dielectric material (line 66-68, column 5). Energized gas originating from the

irradiation furnace is then convey across a pressure drop through the reaction chamber (item 13, Figure 1) and into the vacuum pump. Under the first embodiment shown in Figure 2 Arai adds a perforated support board (item 27, Figure 2) stabilizing a substrate object (item 28, Figure 2). And, as in the disclosure describing Figure 1, maintains all components that distribute and activate the raw unionized gas from the process gas supply. Arai additionally enhances the disclosure described in Figure 1 by thermally isolating and irradiation encasing the ionization chamber zone with upper and lower coolant surfaces (items 20 and 21 respectfully, Figure 2) conveying microwave absorbing water. Arai, however, lacks the application of his disclosed activated gas generator as a plasma effluent gas processing unit. Ransch, Fujitsu Ltd., and Itoga et.al. are all foreign references with only translated titles and abstracts available under the WPAT/JAPIO databases. As of the date of this document the U.S. Patent Translations Department is working on translating each patent or finding an English equivalent document. Translations of the sited documents will be provided to the applicant in the near future. Under the titles and abstracts of these documents Ransch (DD-215706) discloses an invention entitled "Plasma waste gasses cleaning - by passing plasma between reactant plate and vacuum container walls". The waste gases from plasma-etching operations are "cleaned" by passing the gasses in an evacuated chamber over a reactant material in the presence of an inert gas. The assignee, Fujitsu Ltd. (JP51129868A), discloses an apparatus for the treatment of waste gas generated from a semiconductor production process. The gas processing of the plasma effluent is accomplished by oxidation with oxygen or hydrogen peroxide in a plasma generated environment. Itoga et.al. (JP51-129868) disclose "A process for treatment of waste gas". A waste gas treatment

process used in the semi-conductor industry is detailed by Itoga et. al.. Arai is recognized as lacking a waste gas processing appendage that would receive the effluent from the plasma generating operations upstream. The deficiencies of the inventors Ransch, Fujitsu Ltd., Itoga et.al. relative to the disclosure of Arai can not be fully ascertained until the complete translations of the documents are processed. However, under the disclosures of Arai a person of ordinary skill in the plasma gas production art at the time the invention was made would be motivated by the provisions of 40CFR Part 82 to implement an air pollution control unit that would treat the regulated off-gas. 40CFR Part 82 is the Clean Air Act final rule on the protection of stratospheric ozone from the halocarbon contaminants listed under class I and class II in sections 604 and 606 of the Clean Air Act. Considering the art disclosed by Arai, one of ordinary skill in the production of a plasma gas by the method disclosed by Arai's activated gas generator would consider one of two options for off-gas abatement. One method a person of ordinary skill would implement to limit the production of regulated off-gasses would be to construct an off-gas recycle system. The system would collect the process gas from the reaction chamber (13, Figure 2) via exit pipe (30, figure 2) once the containment of such a gas reached a capacity limit. Through a series of added isolation vales, the effluent collected could then be refluxed into the activated gas generator now implemented as an exhaust gas treatment unit containing all the attributes discussed in this claim and its dependent claim. An alternative method for treating the off-gas generated from Arai's activated gas generator is to replicate Arai's generator then connect, in series, the effluent gas produced from the generator at exit pipe (30, figure 2) with the entrance pipe (9b, Figure 2) of the second activated gas generator now implemented as an exhaust

gas treatment unit, the two units in series, containing all the attributes discussed in this claim and its dependent claim.

16. Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Chiu in view of Otsubo et. al..Chiu discloses a monitoring system taught in the experimental section of his patent. Under Chiu's teachings, the plasma extraction reactor is located downstream of a plasma generation unit (GENUS Model 8402 LPCVD) and a residual gas analyzer is connected to the effluent line of the plasma generation unit. Chiu, however, lacks the control method for terminating a process being conducted in the process chamber. Otsubo et.al. teaches a control and etching apparatus for monitoring, controlling, and manufacturing a plasma and the products originating from such processes. Monitoring the plasma etching conditions is accomplished through optical signal processing utilizing a TV camera (item 19, Figure 6), a band-pass filter (item 33, figure 6), and other associated circuitry (lines 8-22, column 5). Figure 6 details a specific component termed an end point decision device (item 20, Figure 6, lines 23-32, column 5). The end point decision device consists of a threshold value signal generator circuit (35b) that receives the output signal Va of the average value extraction circuit (35a) that is connected to the comparitor circuit (34) (lines 50-65, column 5). Otsubo et.al. further discloses that the disclosed circuitry can be altered to any desired triggering error signal. Based on the relative position of the input signal to the error signal, a desired action can be taken to control the process (lines 59-65, column 5), namely stopping the etching process. The person of ordinary skill in the art of designing and controlling the amount of plasma gas that is processed, at the time the invention was made, would find it obvious to implement a slight modification such as

coupling the signal produced from Chiu's residual gas analyzer to the control algorithm set forth by Otsubo et.al. Motivation for this action has already been presented, namely point source emission restrictions.

17. Claim 24 is rejected under 35 U.S.C. 103(a) as being unpatentable over Arai in view of Chiu, Ransch, Fujitsu Ltd., Itoga et.al.,. Arai discloses a microwave induced plasma gas generator. A microwave power generator (item 1, Figure 1) utilizing a microwave tube in conjunction with a magnetron is applied to a waveguide (item 2, Figure 1). Microwave irradiation is subsequently conveyed through an isolator (item 3, Figure 1), power monitor (item 4 Figure 1), and a tuner (item 5 Figure 1) and concludes in an irradiation furnace (item 6, Figure 1). A metal tube (item 8, Figure 1) protruding from the irradiation furnace maintains a magnetic flux while gas pipe (item 9, Figure 1) carrying raw, unionized gas, penetrates metal tube(8) and irradiation furnace (6). The gas pipe(9) originates from a valve and tank assembly (items 11 and 12 respectfully, Figure 1) upstream of the gas flow direction and terminates at a vacuum pump (item 14, Figure 1). The unionized gas carried by the gas pipe penetrating the ionization chamber is energized in the irradiation furnace by allowing microwave energy to penetrate through its dielectric length (item 10, Figure 1). The dielectric material disclosed is allowed to be made of a plasma environment resistant material such as quartz (line 32-34, column 30). The gas outlet extension (item 9c, Figure 2, Figure 7) is also allowed to be constructed of a dielectric material (line 66-68, column 5). Energized gas originating from the irradiation furnace is then convey across a pressure drop through the reaction chamber (item 13, Figure 1) and into the vacuum pump. Under the first embodiment shown in Figure 2 Arai adds a

perforated support board (item 27, Figure 2) stabilizing a substrate object (item 28, Figure 2). And, as in the disclosure describing Figure 1, maintains all components that distribute and activate the raw unionized gas from the process gas supply. Arai additionally enhances the disclosure described in Figure 1 by thermally isolating and irradiation encasing the ionization chamber zone with upper and lower coolant surfaces (items 20 and 21 respectfully, Figure 2) conveying microwave absorbing water. Arai, however, lacks the application of his disclosed activated gas generator as a plasma effluent gas processing unit such as Chiu's plasma extraction reactor's. Arai also lacks a gas analyzer for monitoring the hazardous gas content of the effluent exhaust gas and providing an output signal in relation to the hazardous gas content of the effluent. Chiu discloses an exhaust system apparatus, plasma extraction reactor (lines 66-68, column 2), for treating effluent gas streams from plasma (Figures 1-6). Chiu specifically applies the plasma extraction reactor to utility in the removal of vapor phase environmental contaminants from effluent gas streams generated by semiconductor processing equipment generating plasma states (line 61-68, column 2). Chiu also discloses the location of his plasma extraction reactor relative to a CVD process (lines 1-18, column 6) and more specifically to a GENUS Model 8402 LPCVD reactor (lines 53-58, column 8). Chiu discloses an embodiment where radio frequency driven parallel electrode plates, as part of the plasma extraction reactor, are positioned to intercept effluent gas from the upstream production site and subsequently deposit the gas on the electrode surfaces by nucleation (line 61-68, column 2 through, lines 1-7, column 3, lines 18-23, column 5). Variations on contact area of the reacting effluent are considered and integrated into the design by altering the geometry of the flow path (lines 24-45, column 3). Among the

geometric design considerations of the internal flow chamber put forth by Chiu include a flow path length to ensure sufficient removal of the effluent gas (lines 24-30, column 3), a high ratio of electrode area to reactor volume (lines 11-23, column 3), electrode surface area to flow rate of gas to be optimally set for vapor removal capacity (lines 30-37, column 3). According to the following demonstration, the requirement that the flow path be of sufficient length to provide an effluent gas residence time of at least 0.01s in the exhaust plasma extraction reactor stipulated in claim 12.2 is implicitly satisfied under the teachings of Chiu[5]. Chiu does not explicitly make reference to the flow regime, either turbulent or laminar, when passing the effluent gas through the plasma extraction reactor. Chiu also does not specifically detail the material of construction for the inlet port (14, Figure 1) acting as the exhaust tube protruding from the process chamber claimed in claim 11. However, it would be obvious to one of ordinary skill in the design of a process chamber for processing a substrate and reducing the emissions of hazardous gas to the environment art, at the time the invention was made to discriminate a material of construction for the exhaust tube (85, Figure 1). The person of ordinary skill in the art would be motivated to select a material, such as a ceramic, for the exhaust tube that would optimally service its function, namely as a conduit for the effluent heated gas existing in a corrosive plasma environment in addition to sufficiently transmit microwave energy. Chiu also does not make reference to the surface characteristics of the flow path. More related prior art by Ransch, Fujitsu Ltd., and Itoga et.al. (all sited by Chiu) disclose gas effluent treatment methods from plasma processing operations. Ransch, Fujitsu Ltd., and Itoga et.al. are all foreign references

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[5]Refer to calculation sheet.

with only translated titles and abstracts available under the WPAT/JAPIO databases. As of the date of this document the U.S. Patent Translations Department is working on translating each patent or finding an English equivalent document. Translations of the sited documents will be provided to the applicant in the near future. Under the titles and abstracts of these documents Ransch (DD-215706) discloses an invention entitled "Plasma waste gasses cleaning - by passing plasma between reactant plate and vacuum container walls". The waste gases from plasma-etching operations are "cleaned" by passing the gasses in an evacuated chamber over a reactant material in the presence of an inert gas. The assignee, Fujitsu Ltd. (JP51129868A), discloses an apparatus for the treatment of waste gas generated from a semiconductor production process. The gas processing of the plasma effluent is accomplished by oxidation with oxygen or hydrogen peroxide in a plasma generated environment. Itoga et.al. (JP51-129868) disclose "A process for treatment of waste gas". A waste gas treatment process used in the semi-conductor industry is detailed by Itoga et.al.. Arai is recognized as lacking a waste gas processing appendage that would receive the effluent from the plasma generating operations upstream. Considering the art disclosed by Arai, one of ordinary skill in the production of a plasma gas by the method disclosed by Arai's activated gas generator would consider one of two options for off-gas abatement without further modification from Chiu, Ransch, Fujitsu Ltd., Itoga et.al.. One method a person of ordinary skill would implement to limit the production of regulated off-gasses would be to construct an off-gas recycle system. The system would collect the process gas from the reaction chamber (13, Figure 2) via exit pipe (30, figure 2) once the containment of such a gas reached a capacity limit. Through a series of added isolation vales, the effluent collected could

then be refluxed into the activated gas generator now implemented as an exhaust gas treatment unit. An alternative method for treating the off-gas generated from Arai's activated gas generator is to replicate Arai's generator then connect, in series, the effluent gas produced from the generator at exit pipe (30, figure 2) with the entrance pipe (9b, Figure 2) of the second activated gas generator now implemented as an exhaust gas treatment unit, the two units in series. Chiu is recognized as lacking a detailed disclosure of a specific plasma generating instrument that first generates a plasma gas, processes a substrate in a reaction chamber, and subsequently discharges the effluent gas from the processing step. Chiu's plasma extraction reactor is disclosed as an instrument that will treat production effluents from semiconductor processing equipment. The deficiencies of the remaining inventors Ransch, Fujitsu Ltd., Itoga et.al. relative to the contents of this application for a letters patent can not be fully ascertained until the complete translations of the documents are processed. However, under the disclosures of Arai in view of Chiu a person of ordinary skill in the plasma gas production and processing art at the time the invention was made would be motivated by the provisions of 40CFR Part 82. 40CFR Part 82 is the Clean Air Act final rule on the protection of stratospheric ozone from the halocarbon contaminants listed under class I and class II in sections 604 and 606 of the Clean Air Act. Coupling the technology of Arai in view of the Chiu to arrive at a semiconductor processing apparatus that will comply 40CFR Part 82 is an action that one of ordinary skill in the plasma gas manufacturing art, at the time the invention was made, would have to implement.

18. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Arai as applied to claims 11,12,13,14,16 and 25 above, and further in view of Otsubo et.al.. Arai discloses a microwave induced plasma gas generator. A microwave power generator (item 1, Figure 1) utilizing a microwave tube in conjunction with a magnetron is applied to a waveguide (item 2, Figure 1). Microwave irradiation is subsequently conveyed through an isolator (item 3, Figure 1), power monitor (item 4 Figure 1), and a tuner (item 5 Figure 1) and concludes in an irradiation furnace (item 6, Figure 1). A metal tube (item 8, Figure 1) protruding from the irradiation furnace maintains a magnetic flux while gas pipe (item 9, Figure 1) carrying raw, unionized gas, penetrates metal tube(8) and irradiation furnace (6). The gas pipe(9) originates from a valve and tank assembly (items 11 and 12 respectfully, Figure 1) upstream of the gas flow direction and terminates at a vacuum pump (item 14, Figure 1). The unionized gas carried by the gas pipe penetrating the ionization chamber is energized in the irradiation furnace by allowing microwave energy to penetrate through its dielectric length (item 10, Figure 1). The dielectric material disclosed is allowed to be made of a plasma environment resistant material such as quartz (line 32-34, column 30). The gas outlet extension (item 9c, Figure 2, Figure 7) is also allowed to be constructed of a dielectric material (line 66-68, column 5). Energized gas originating from the irradiation furnace is then convey across a pressure drop through the reaction chamber (item 13, Figure 1) and into the vacuum pump. Under the first embodiment shown in Figure 2 Arai adds a perforated support board (item 27, Figure 2) stabilizing a substrate object (item 28, Figure 2). And, as in the disclosure describing Figure 1, maintains all components that distribute and activate the raw unionized gas from the process gas supply. Arai additionally enhances the disclosure

described in Figure 1 by thermally isolating and irradiation encasing the ionization chamber zone with upper and lower coolant surfaces (items 20 and 21 respectfully, Figure 2) conveying microwave absorbing water. Arai, however, lacks a gas analyzer for monitoring the hazardous gas content of the effluent exhaust gas and providing an output signal in relation to the hazardous gas content of the effluent in order to control the process that is being measured. Otsubo et.al. teaches a control and etching apparatus for monitoring, controlling, and manufacturing a plasma and the products originating from such processes. Monitoring the plasma etching conditions is accomplished through optical signal processing utilizing a TV camera (item 19, Figure 6) and image comparison to images that are entered into the image memory circuit (item 44 of Figures 10(a) and 10(c), lines 29-31, column 7). Other system components include a band-pass filter (item 33, figure 6), and associated circuitry (lines 8-22, column 5). Figure 6 details a specific component termed an end point decision device (item 20, Figure 6, lines 23-32, column 5). The end point decision device consists of a threshold value signal generator circuit (35b) that receives the output signal Va of the average value extraction circuit (35a) that is connected to the comparitor circuit (34) (lines 50-65, column 5). Otsubo et.al. further discloses that the circuitry can be altered to any desired triggering error signal (lines 62-68, column 5). Based on the relative position of the input signal to the error signal, a desired action can be taken to control the process (lines 59-65, column 5), namely stopping the etching process by a signal provided by the high frequency power source-control circuit (item36, Figure 6). A person of ordinary skill in the art of designing and controlling the amount of plasma gas that is processed, at the time the invention was made, would find it obvious to implement and enhance the

teachings of Otsubo et.al. into the established residual gas analyzer monitoring system disclosed by Chiu. Control of Otsubo et.al.'s processing conditions is mediated through decision making of the end point decision device which provides power to the radio frequency power source (16) that directly influences the plasma and hence the processing conditions. In another embodiment shown in Figure 8, Otsubo et.al. end point decision and control device (20) consists of a computer readable sampling circuit (item 41, figure 8, lines 4-13, column 7). The process control algorithm set forth by Otsubo et.al. represent a template of knowledge from which Chiu's effluent residual gas analyzer can be obviously modified by, for example, coupling the signal from Chiu's RGA to the control and decision circuitry taught by Otsubo et.al.. Instead of a optical decision based algorithm, a setpoint for concentration can be used from the RGA. The operating power level, and hence the processing conditions, of the gas energizer is the same for Otsubo et al.'s terminal control point (item 16, all Figures). Implementations of alarming conditions would be obvious to one of ordinary skill in the art in view of the teachings of Otsubo et.al. with the same additions to Arai and modifications of Otsubo et.al.. Reagent gas addition to the processing environment to reduce the environmental impact to the environment is disclosed by Fujitsu Ltd.. Process termination based on the decision circuitry is disclosed by Otsubo et.al..

19. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Examiner Rudy Zervigon whose telephone number is (703) 305-1351 and electronic mail is rudy.zervigon@uspto.gov. The examiner can normally be reached on a Monday through Friday schedule from 8am until 5pm. The official AF fax phone number for the 1763 art unit

is (703) 305-3599. Any Inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Chemical and Materials Engineering art unit receptionist at (703) 306-1351.

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Rudy Zervigon - RZ

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